Vol. 5, No. 2 10 cents May, 1918

Everyday ENGINEERING Magazine

A MAGAZINE OF PRACTICAL MECHANICS FOR EVERYDAY MEN

MODEL ENGINEERING NUMBER

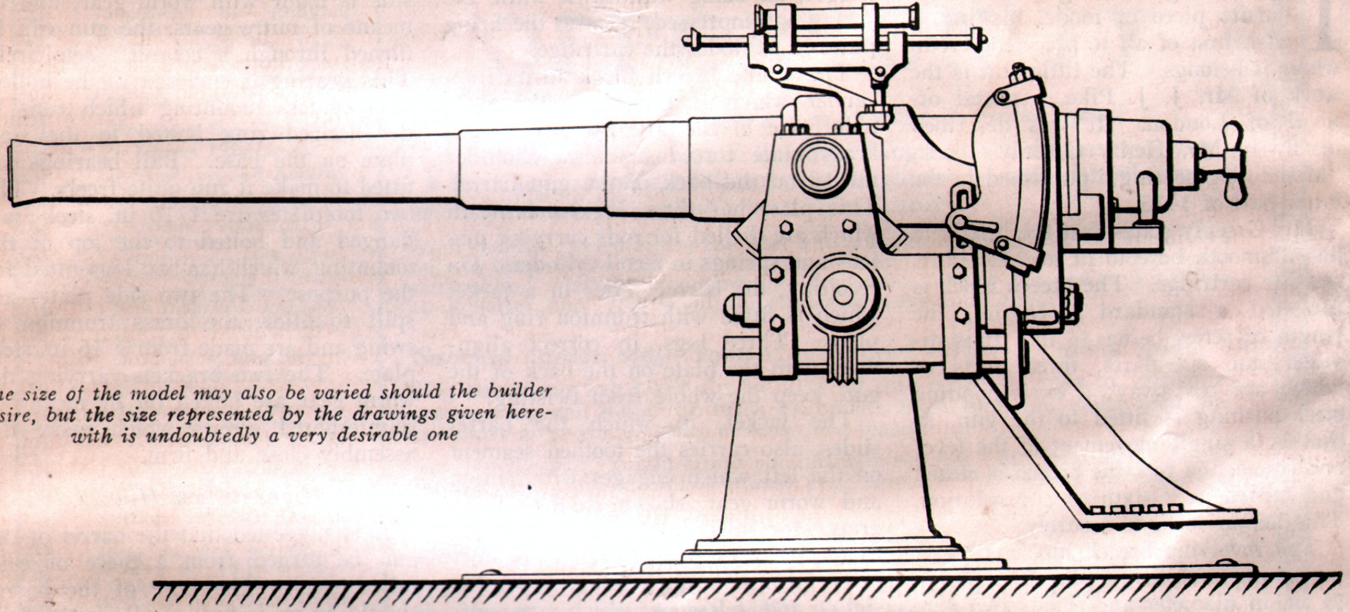
Notice to the Reader—When you have finished your use of this magazine for reading and reference place a 1-cent stamp on this centric with the bore is to turn the profile, using the bore for center holes. If a sufficiently long drill cannot be obtained, and it certainly cannot in the standard types, the builder must need resort to a substitute. This is readily found in an extension to the shank of a regular drill. After drilling the hole as far as possible with the ordinary drill, holding the stock in the chuck and the drill in a tailstock chuck, the builder may turn down the soft shank of the drill to make a tight fit into a hole drilled into the end of a piece of steel rod, .22 in. in diameter and long enough to extend the drill clear through the gun barrel. The joint between drill and rod may readily be soldered providing it is thoroughly cleaned and made free from oil before applying the flux.

We regard the job of rifling as one beyond the capabilities of the amateur. While it is necessary for strict fidelity to prototype, it adds nothing to the appearance of the gun and it enormously complicates the construction of the barrel. It is assumed that the gun will be used for blank cartridges only if it is fired at all, and in this event, rifling is quite superfluous.

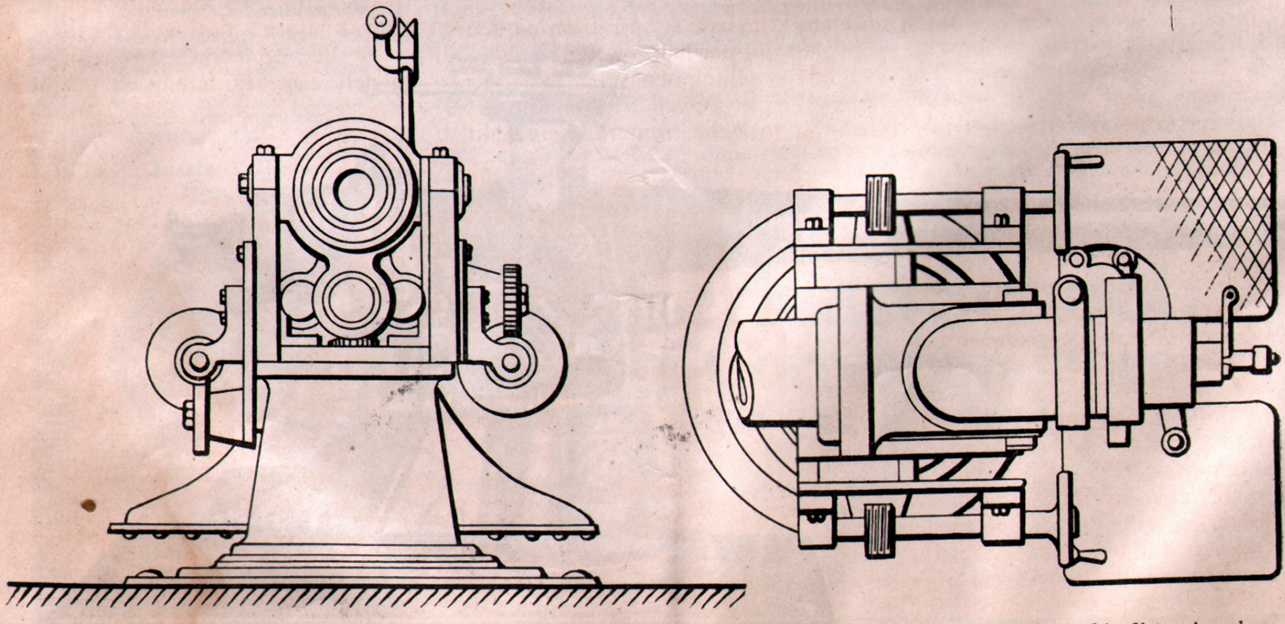
The barrel may be given a fine blued finish by working it down very carefully with dead smooth files and the finest emery cloth, then, after cleaning thoroughly and running a holding wire right through the barrel so that finger marks will be unnecessary, the barrel may be heated over a bunsen flame very carefully until it begins to turn color; it is then immediately dipped in an oil bath and afterward carefully wiped free from oil with a soft cloth. The heating process is then repeated and the oil bath given a second time. This may again be repeated if necessary until the desired blue color is obtained. The final polishing is with the soft cloth, no abrasive being used as the blue color is merely a coating which will be scratched off if an abrasive or polishing medium is applied.

The conical base is best made from a casting but it can, of course, be turned from a piece of heavy pipe turned to a running fit in the flange. This latter method of procedure, of course, obviates the necessity for delay in procuring castings which are difficult to get in single lots these days.

The original model of Mr. Pike was patterned after a six-inch naval gun of British design. The details may be modified in the event that the builder desires to emulate any other particular type.



The size of the model may also be varied should the builder desire, but the size represented by the drawings given herewith is undoubtedly a very desirable one



The drawings are the exact size of the finished model. The prospective builder may therefore obtain his dimensions by direct measurement of the drawing

PRACTICAL MECHANICS
FOR EVERYDAY MEN

Everyday
ENGINEERING
Magazine

IT TELLS YOU HOW TO
MAKE AND DO THINGS

VOLUME V MAY, 1918 NUMBER II

Design for Model Rapid-Fire Naval Gun

Great interest centers at this time in models of a military character. The pure beauty of design and execution in this model makes it worthy of notice.

By Thomas Stanley Curtis

IN presenting the design for this exquisite piece of model making, I wish first of all to place the credit where it belongs. The little gun is the work of Mr. J. J. Pike, a postal official of London. It was described briefly in Mr. Henry Greenly's book, "Model Engineering," published in the latter part of 1915.

Mr. Greenly states that the little gun has a smooth bore to fit a .22 calibre, rim-fire cartridge. The breech block is threaded a standard 7/16 in., the length of screw being ⅜ in. It is divided into six parts, three parts of which are cut away; a corresponding steel bushing is fitted to the gun, so that by a single movement of the lever and connection rod, the breech is closed and turned in a sixth of a revolution. This action locks it securely.

The revolving breech block is bored for spring and firing pin; this pin is ⅛ in. in diameter and it has two flats made with a file. A forked trigger is fitted to engage these two flats; this trigger, on being withdrawn while the spring is compressed, releases the firing pin and explodes the cartridge.

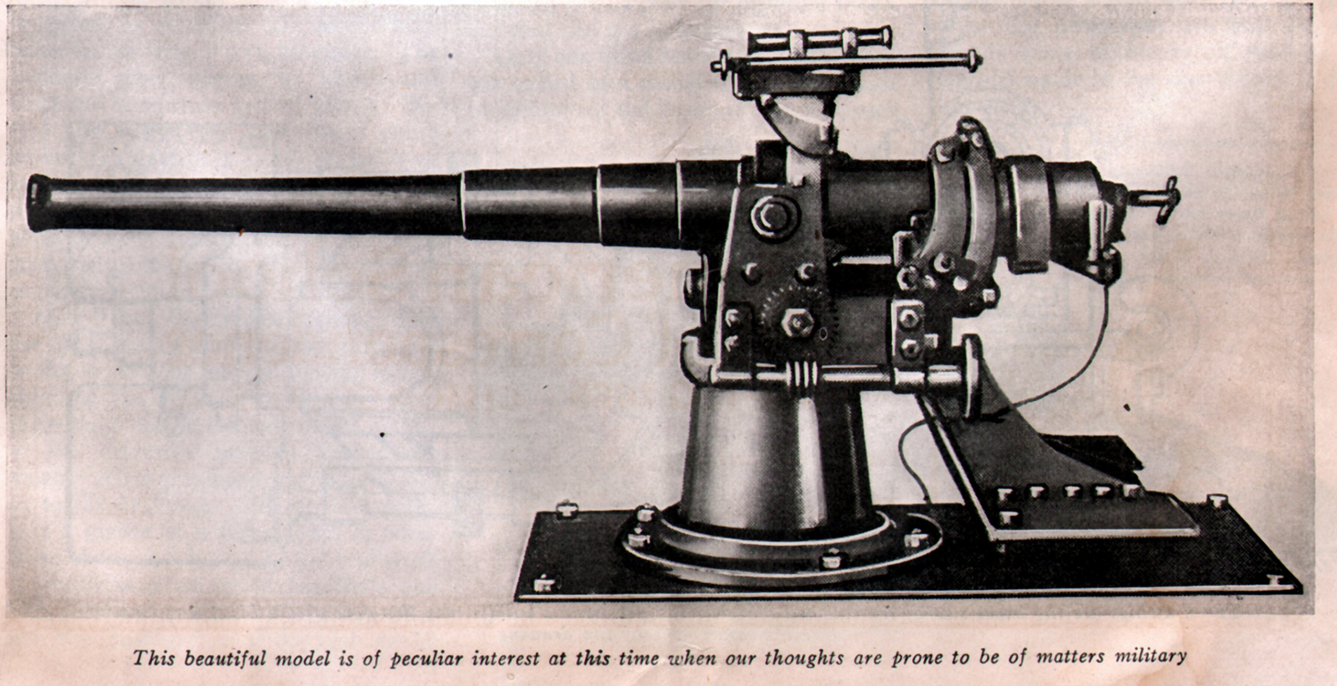
The whole breech block turns in a carrier which is hinged to the right hand side of the gun by means of a brass plate forced up to a shoulder turned on the back of the gun barrel. This plate has three lugs underneath which are drilled for rods carrying pistons and springs in recoil cylinders. On recoiling, the barrel slides in a jacket which is fitted with trunnion ring and plate. Three lugs, in correct alignment with the plate on the back of the gun, keep the whole from twisting.

The jacket, in which the barrel slides, also carries the toothed segment on the left which engages with pinion and worm gear, shown in the photograph, for raising or lowering the gun by means of the handwheel. The only other fittings the jacket carries are the sights and telescope which are self-explanatory.

The handwheel on the right hand side is made with worm gear, and by means of mitre gears, the gun can be turned through a complete semicircle. This gearing is enclosed in the hollow steel conical mounting which runs in the flanged ring bolted to the steel plate on the base. Ball bearings are fitted to make it run quite freely. The two footplates are 1/16 in. steel plate flanged and bolted to the top of the mounting, which has two lugs fitted for the purpose. The two side plates are split to allow the brass trunnion to swing and are made from 3/16 in. steel plate. The two brackets carrying the worm gear are bolted on by means of counterbored screws which make the assembly close and firm.

Construction Hints.

It is suggested that the barrel of the gun be turned from a piece of cold rolled steel. The bore of the barrel should be made first of all, as the drill may run out slightly and in that event the only way to make the exterior con-



This beautiful model is of peculiar interest at this time when our thoughts are prone to be of matters military

Experimental Science

PART II—The Conduction of Electricity Through Gases[*]

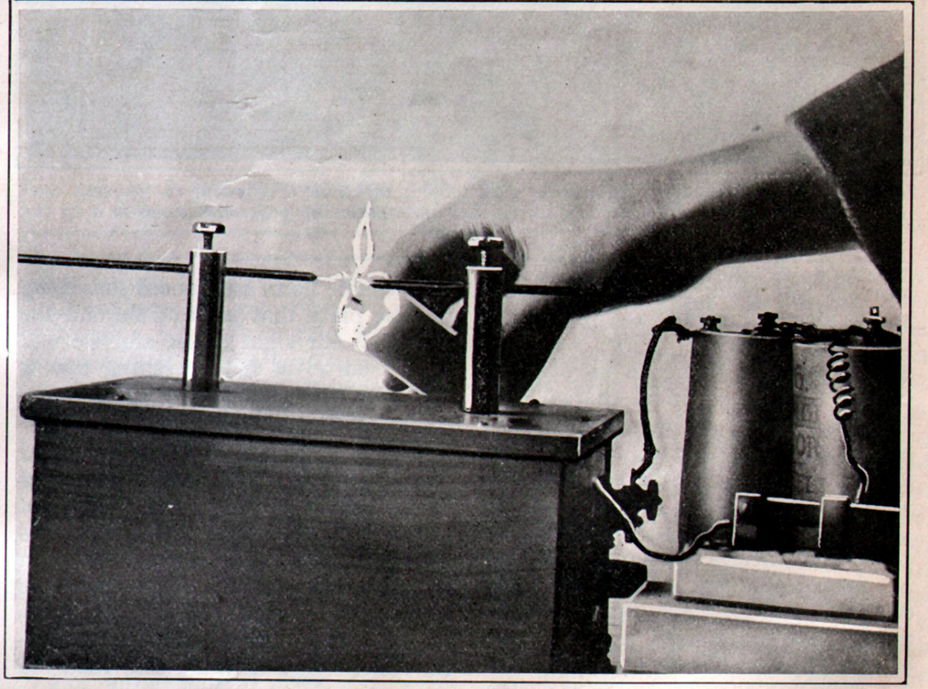
How Gases Are Changed From Non-Conductors of Electricity to Conductors by Simple Processes

By Raymond Francis Yates

DURING recent years, much investigation has been made of the electrical conductivity of gases, and through a series of most significant experiments, performed by some of the world's greatest minds, this peculiar phenomenon stands paramount among the scientific problems of the twentieth century. It is indeed fortunate that the layman can comprehend these wonderful experiments and that the home scientist can reproduce some of them with very simple apparatus. At first sight, the title "Conduction of Electricity Through Gases" may appear coldly technical and somewhat meaningless to the lay mind, but nevertheless the subject possesses profound interest when elucidated in everyday terminology.

Before we enter into the gist of our subject, we will consider for a moment, just what a gas is in relation to the other states of matter, of which there are three, solid, liquid and radiant. Having in mind that all tangible matter (this does not include radiant matter) is composed of those tiny particles we are pleased to call molecules; solids represent the most compact state of matter. In studying the structure of solids, we find the molecules are crowded very closely and the intervening space between them is inappreciably small. In the liquid state of matter, the molecules are farther apart and, as a result, the substance possesses less stability and has no definite shape, this being determined by the confines of its surroundings. In the gaseous state of matter, we find that the molecules are still further removed from one another, so far indeed that we are unable to detect a gas with two of our most reliable senses, sight and touch. In fact, gases that have no odor or color are, as far as our senses are concerned, intangible. A gas is even more unruly than a liquid in its physical behavior; it insists on dispersing and the migration of its ultimate parts are only limited by the walls of the vessel in which it is contained. Thus, we see that a gas is as far removed from a liquid as a liquid is from a solid. Some elements of matter, such as oxygen, nitrogen, chlorine and hydrogen are gaseous in their natural state, a very few are liquid and most are solid.

An electrical conductor is a substance that permits an electrical current to flow through it freely. An insulator is a substance that offers great resistance to the flow of electricity. Strange to say, although our subject has to do with the electrical conductivity of gases, the gaseous state of matter is generally classed with the non-conducting substances—gases of all natures are considered insulators of the highest order. This fact adds interest to our discussion; we are going to learn of the wonderful processes whereby a gas undergoes a fairy-like transmutation in its electrical properties and permits a current to pass through it with ease.



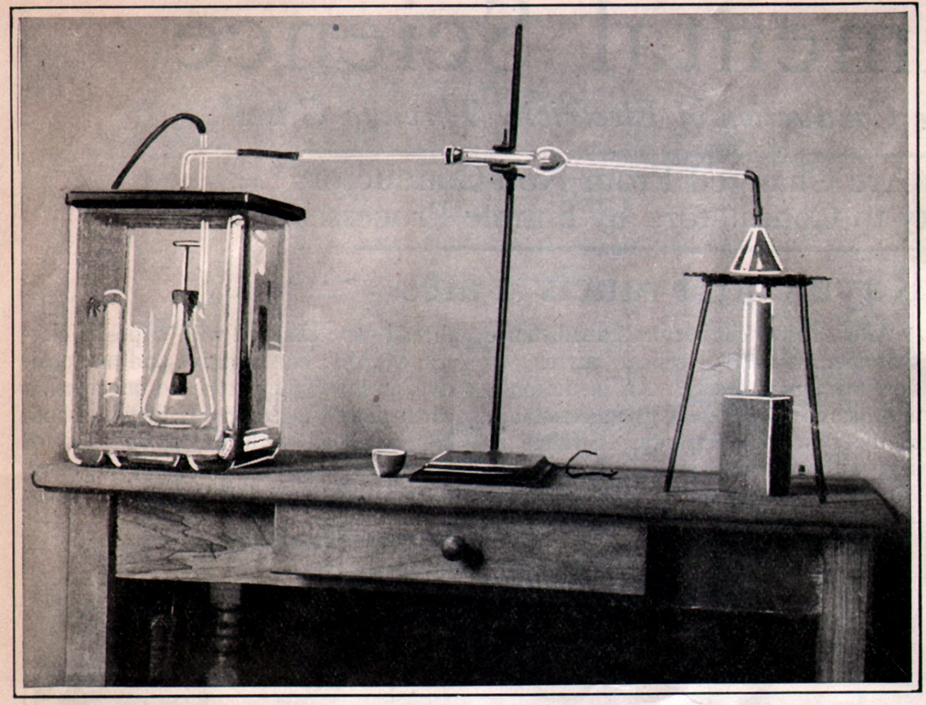
A candle flame brought into proximity with a spark gap which has been lengthened until the spark can no longer pass ionizes the air and permits the discharge to take place with ease

We will start our investigations into the electrical conductivity of gaseous matter with a candle and an electroscope. The candle, being an ordinary one, needs no explanation, but not so with the electroscope, as it is very possible that its action may not be understood by some, although it is extremely simple. We all learned in the Physics class back at school, that like charges of electricity repel one another and unlike charges attract. In fact, we might recall to mind the experiment in which two tiny pith balls suspended on a thread were charged with opposite electric charges; one negative and one positive, and how they attracted one another when placed together. If they had both been charged with the same kind of electricity, for example both negative, they would have repelled one another. The operation of the electroscope is based upon just these principles. It consists of a small metal plate fastened to a metal rod. A piece of gold leaf is attached to the plate and the whole thing is placed in a bottle to protect it. If we were to charge a rod of sealing wax with negative electricity and bring it into proximity to the electroscope, the gold leaf would fly out from the metal and this would indicate the presence of the charge on the sealing wax. This action of the gold leaf is caused by the sealing wax inducing a negative charge of electricity in the plate and the gold leaf. As the plate and gold leaf are charged with the same electricity, and in accordance with our previous explanation, the leaf is repelled and flies outward from the surface of the plate.

Having now explained the principles and action of the electroscope and having the little gold leaf in a charged condition where it tends to assume a position at right angles to the plate, we

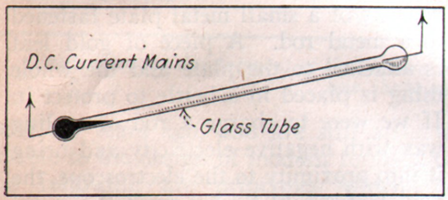
---

[*] This is the second of a series of articles on practically-applied science. The next will appear in an early issue.



Ionized gas passed through a chamber of glass wool is incapable of affecting the charged electroscope in the glass tank on the left, having lost the conducting properties given to it by the candle

may ask just when the leaf will return to its former position and just what will make it do so. First, we know that in order to return to its position, it must lose its electrical charge. We find that it will do this gradually if permitted to stand and, furthermore, that this gradual discharge is caused by the charge leaking into the air; the air being a conductor of electricity to a *very slight extent,* carries off the charge. At first, scientists would not admit that this leakage took place through the air, but maintained it was caused by the poor insulating qualities of the materials that made up the electroscope. However, we have conclusive proof today that this leakage takes place into the atmosphere, and in entering into the study of the electrical conductivity of gases, this simple experiment has a peculiar significance.



A commercial mercury vapor lamp, depending on the conductivity of mercury vapor for its operation

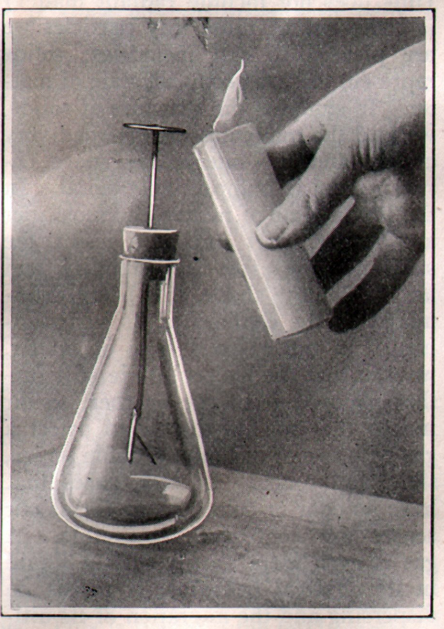
If we charge the elctroscope and bring the flame of the lighted candle in proximity to it, something very wonderful happens—the little gold leaf rapidly loses its charge and falls back into its normal position. Somebody immediately suggests that the flame has increased the conductivity of the air and thereby caused the charge to leak away more rapidly. This is exactly what happens. The innocent looking little candle flame has caused something to take place that is quite beyond the power of our sight to see and we will satisfy ourselves by concluding that it increases the conductivity of the surrounding air by heating it.

We have learned that the electrical conductivity of gases can be increased by the agency of heat. But this is not the only agency that will cause this change to take place. Gases are changed from insulators to conductors under the influence of X-rays, cathode rays, gamma rays, beta rays, alpha rays, and ultra-violet light; they are also rendered conductive in the presence of molten phosphorus and glowing metals. If this is true, then, all these agents should discharge the electroscope just as the candle flame did. We find this to be true. In the presence of a powerful source of ultra-violet light or any other one of the invisible rays mentioned, the electroscope loses its electrical charge.

Gases that have been rendered conductive do not retain this property for any great length of time, but that they do retain it for a short period may be proven by a simple experiment. If a gentle current of air is led from the vicinity of the candle flame to an electroscope, we find that it still retains its conductivity after being transmitted through the length of the tube. If we make this glass tube between the candle and the electroscope long enough, however, we find that the gas will lose its conductivity before it reaches the electroscope chamber. It has been found that a gas is capable of holding its property of conductivity only four or five minutes. It loses it, but whence does it go? Is it a condition or a thing that causes it to take on this property temporarily?

In our experiment with the candle showing how the gases retain their conductivity, let us interpose a little chamber of glass wool between the candle and the electroscope chamber so that the gas will pass through the glass wool before it reaches the electroscope. We are surprised to find that the gas no longer possesses its conducting property and is not capable of discharging the electroscope. If, instead, we bubble the gas through water before it reaches the electroscope, the same astonishing result becomes manifest.

We have learned that by its passage through the wool it was deprived of its property of conductivity. This conductivity is known to be the result of particles which are merely atoms of the gas carrying an electric charge which may be either positive or negative. It is these particles that conduct the electricity. They are technically known as ions and the process of producing them is known as ionization. We may look upon an ion, then, as an atom or group of atoms carrying an electric charge. The gas which contains these charged atoms or ions does not exhibit either a negative or positive charge itself because it contains an equal number of both positively and negatively charged ions. By passing the gas through glass wool or water, the ions were discharged and the gas rendered non-conducting.

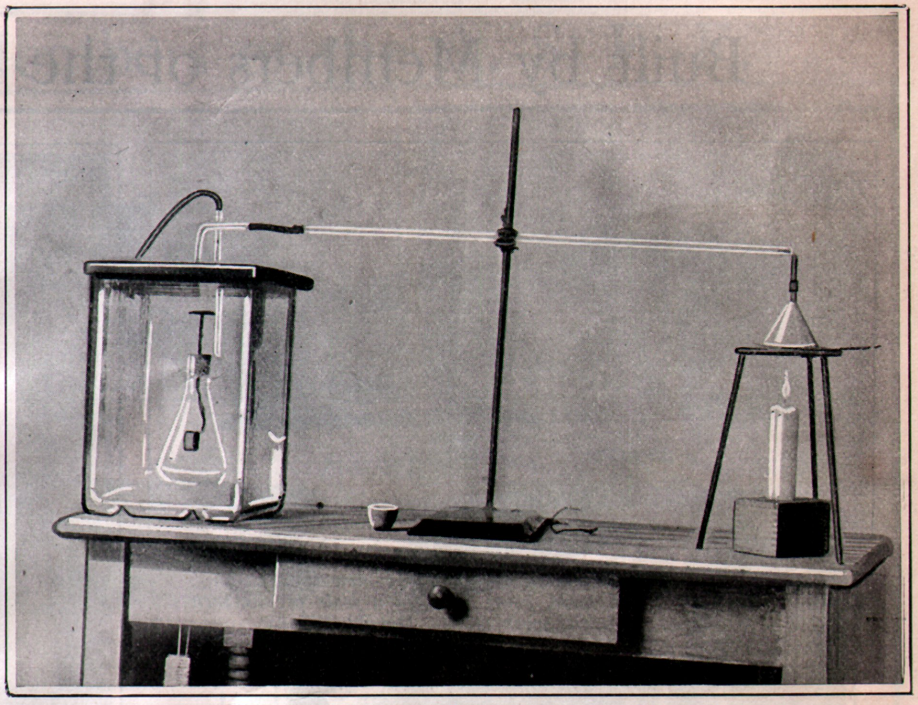


A gold leaf electroscope discharged by bringing a candle near it. The charge leaks away through the ionized air

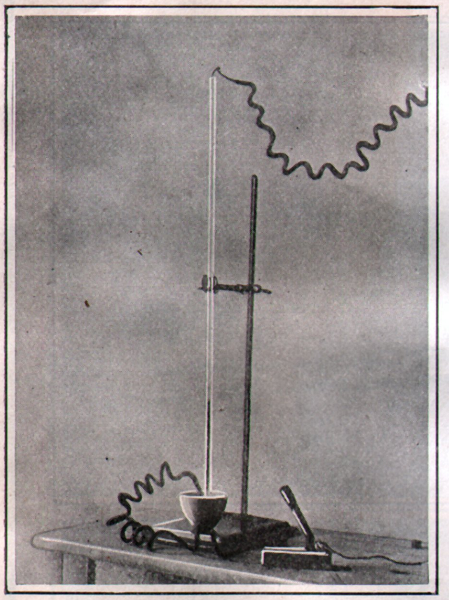
There is a phenomenon closely associated with the conductivity of ionized gases and that is the conductivity of rarefied air. If a glass vessel equipped with two electrodes is connected to a vacuum pump and part of the contained air extracted, we find that a beautiful, soft discharge takes place across the space between the electrodes if they are connected to an induction coil. As we increase the vacuum the discharge takes place silently in a steady thread of luminosity, and if we carry the vacuum still higher, the whole tube becomes illuminated with a soft glow. If the air becomes too rarefied, we find that its good conducting properties are overcome and the discharge takes place with difficulty.

We may make a few simple but very instructive experiments to substantiate our hypothesis on the conductivity of gases. A small induction coil is connected to a spark gap and the space between the points of the gap are adjusted so that a spark just fails to pass. If we bring a lighted candle in the vicinity of the gap, the air in the intervening space between the electrodes will become ionized and a spark will pass. If we bring an excited X-ray tube in proximity to the gap, the same result will be produced or if a piece of red hot iron or carbon is used, the air will be ionized and the spark will pass.

At this point, it may be interesting to learn of another way in which an ionized gas is robbed of its ability to conduct a current of electricity. Having in mind that the conductivity of the gas is caused by the presence of ions and knowing that these ions are atoms of matter carrying both positive and negative charges, we conclude that it would be quite possible to take the positive ions out of the gas by bringing the gas in contact with a negatively charged body and a positively charged body to extract the negative ions. This is a very reasonable conclusion, and is, in fact, quite true, as an ionized gas will be restored to its original non-conducting state by passing it between two metal plates, one charged negatively and the other positively. The positive plate attracts the negative ions and neutralizes them, and vice versa.



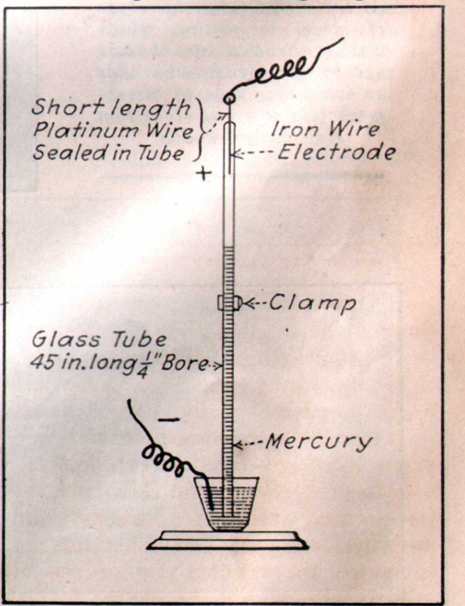
The air from the vicinity of the candle flame may be passed through the glass tube without losing its conducting properties, and still discharges the electroscope



This simple mercury vapor lamp can be readily constructed by the experimenter

From a scientific standpoint, vapor is considered to be a gaseous condition of matter, and, under suitable conditions some vapors will conduct electricity very readily. This is notably the case with the vapor of mercury. But we must not confuse the electrical conductivity of mercury vapor with that of ionized gases. In its normal condition, mercury is a very good conductor of electricity and therefore its vapor is also a comparatively good conductor without becoming ionized. Mercury vapor, unlike ionized gases, becomes incandescent when a heavy current of electricity passes through it, and mercury is used for this purpose in the construction of mercury vapor arc lights. We are familiar with these lights in photographic studios where their bluish rays give every object they fall upon a ghostly appearance. The general scheme of the mercury vapor lamp is shown in the drawing. When it is desired to light the lamp, it is tilted, which causes the mercury to run from one end of the lamp to the other. In doing this, the mercury leaves a trail of vapor in its wake and the current follows this vapor until a complete arc is established from one end of the tube to the other.

A very simple mercury vapor arc lamp that may easily be constructed by the home experimenter is shown in the photograph and diagramatically in the drawings. About one pound of mercury will be needed to operate the lamp. Part of this mercury is placed in a dish and the tube filled with it while inverted. The tube is then inverted and the mercury is prevented from escaping by placing the finger over the end. The end of the tube is then immersed in the mercury contained in the dish and the finger taken away. We then have what is known as a Torricellian vacuum in the tube caused by the mercury pushing the air out before it as we inverted the tube. If we connect this lamp to the lighting circuit, it will perform just like larger commercial lamps. However, owing to the fact that we cannot tilt our lamp every time we wish to light it, we must first connect it to a source of high voltage current such as an induction coil. This will increase the conductivity of the vacuum by causing more mercury to vaporize; the lamp will then operate on the lighting circuit.


Short length Platinum Wire Sealed in Tube
Iron Wire Electrode
+
Clamp
Glass Tube 45 in. long 1/4" Bore
−
Mercury

A diagram of the experimental mercury vapor lamp described in the text